

# EPIDEMIOLOGY

## Age-bridging among young, urban, heterosexual males with asymptomatic *Chlamydia trachomatis*

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**Objectives:** To determine the prevalence of age-bridgers among urban males aged 14–24 years, asymptotically infected with chlamydia and to determine factors that distinguish age-bridgers from non age-bridgers. An index was defined as an age-bridger if within 2 months, he had had at least two sexual partners who differed from him in age by  $\geq 2$  years.

**Methods:** Infected males provided data about themselves and up to four sexual partners in the past 2 months. Bivariate and multivariable logistic regression was used in the analysis.

**Results:** The prevalence of age bridging was 21% in Baltimore and 26% in Denver. In both cities, in bivariate analysis, age-bridgers and their partners engaged in significantly more risky sexual behaviours. In adjusted multivariable analysis after controlling for number of sexual partners, age bridging was associated with having a sexual partner in the past 2 months, who, at time of last sexual intercourse, was drinking.

**Conclusion:** Age-bridgers represented major proportions of the study populations and, along with their sexual partners, were more likely to engage in risky sexual behaviours. Male age-bridgers may be key players in the transmission of sexually transmitted infections among youth linking age-disparate sexual networks.

Despite the urgent need, there continues to be a lack of understanding as to why ethnic minority females, particularly adolescents, are at such high risk of sexually transmitted infections (STIs) including HIV in the US compared with non-ethnic minority females.<sup>1</sup> Heterosexual transmission is the main mode of infection for almost all adolescent girls, and most infections occur among African-American girls.<sup>2–3</sup> Condom use alone does not explain racial/ethnic differences. Thus, examining patterns of sexual partnering in this population may yield important clues to the source of infection.

Specific patterns of heterosexual partnering, such as having an older sexual partner or age-mixing, have been shown to be prevalent among adolescent females and to be associated with increased risks for STIs even after controlling for condom use.<sup>4–9</sup> Data from the National Longitudinal Study of Adolescent Health showed a 1.46 increased odds ratio (95% confidence interval (CI) 1.22 to 1.75) for a self-reported STI if the adolescent's sexual partner was  $\geq 2$  years older.<sup>5</sup> There have been very few studies, however, to show how these patterns may enhance the risk for STIs among adolescent females.

One hypothesis is that the increased risk is due to the linking of low and high-STI risk networks.<sup>10–13</sup> Specifically, the older male sexual partners of adolescent girls may act as a bridge between younger, low-risk women and older, high-risk women such as commercial sex workers and drug users. The hypothesis extends beyond age-mixing and places sexual dyads within a broader sexual network arena, recognising that links between networks, in this case age-bridgers, may provide an important conduit for STI transmission. Furthermore, the increased risk associated with age-bridging may be particularly relevant in urban areas, where high- and low-risk networks may be in closer proximity both in geographical and network terms, male-to-female ratios may be imbalanced, and rates of STI and HIV infection are greater, thus increasing the likelihood of disease transmission.<sup>2–14–15</sup>

In part, the dearth of research around this hypothesis is related to the difficulty and cost associated with sexual partner

studies and the difficulty in recruiting minority males into research studies. Additionally, few young men access the healthcare system for STI testing or treatment, and few infected, asymptomatic young men perceive themselves to be at risk for an STI.<sup>16–17</sup> The result is that, there is very limited information about the male sexual partners of young, ethnic minority females and even less information about those infected with STI.

As part of the Centers for Disease Control and Prevention-funded, four-city (Baltimore, Denver, San Francisco, Seattle) male chlamydia screening project, two cities (Baltimore and Denver) collected data to learn more about the age-bridging patterns of adolescent and young adult males in these two urban settings. Testing occurred at venues such as STI clinics, adolescent primary care clinics, school-based health clinics, drug treatment programmes, street outreach programmes, community-based organisations, health fairs and juvenile detention centres. Asymptomatic, infected males were then recruited into a longitudinal research study. As part of the study, males were interviewed about themselves and their sexual partners.

The main objective of this analysis was to determine the prevalence of age-bridging among a heterosexual, urban, predominantly minority male population, aged 14–24 years and asymptotically infected with chlamydia. The second objective was to determine individual and sexual partner characteristics and behaviours, which mainly distinguished age-bridgers from non age-bridgers. An index was defined as an age-bridger if within 2 months he had had at least two sexual partners who differed from him in age by  $\geq 2$  years. Age-bridging was analysed within a 2-month time period as a conservative estimate of the duration of infection of chlamydia and thus the period of transmissibility.

**Abbreviation:** STI, sexually transmitted infection

## METHODS

### Participants

The study methods have been reported previously.<sup>18–20</sup> Briefly, as part of the project, males were screened for chlamydia infection by urine-based testing using either polymerase chain reaction (Roche Molecular Diagnostics, Indianapolis, Indiana, USA) or strand displacement amplification (ProbeTec, Becton-Dickinson, Sparks, Maryland, USA). Trained outreach workers then contacted infected males, arranged for treatment, and notified sexual partners. Asymptomatic chlamydia-positive, young males, aged 14–24 years, were recruited for a longitudinal study between February 2001 and March 2003, in Denver and Baltimore. Heterosexual participants from non-correctional venues and their baseline information were selected for this analysis.

### Procedures

Participants were interviewed about themselves and up to four of their most recent sexual partners during the past 2 months and received US \$25.00 for their time and effort. Written informed consent was obtained from all participants and this study was approved by the Colorado Multiple Institutions Review Board, the Joint Committee on Clinical Investigation at the Johns Hopkins University School of Medicine, Maryland, USA and the Centers for Disease Control and Prevention Institutional Review Board.

### Measures

Survey information including demographics, sexual behaviour and drug use were reported by the participants both on themselves, and for selected characteristics, on their recent sexual partners. All sexual partner characteristics were recoded as indicator variables attributed to the participant.

### Demographics

#### Age

Participants provided their date of birth and the age of their sexual partners.

#### Race/ethnicity

Responses were recorded as the most important self-identified race including white, African-American, Asian/Pacific Islander and other. In the Baltimore questionnaire, Hispanic or Latino ethnicity was an additional category. In the Denver questionnaire, Hispanic or Latino ethnicity was a separate question and race and ethnicity were combined to create categories of white (non-Hispanic), African-American, Hispanic and other.

#### Working and/or School status

Separate questions were asked about current working and/or current school enrolment and about the current school enrolment of each sexual partner.

### Sexual behaviours

#### STI history

Participants reported whether they and to the best of their knowledge, their sexual partner had ever been diagnosed with an STI.

#### Number of sexual partners (control variable)

Number of sexual partners in the past 2 months was solicited from the participant.

#### Types of risky sexual partners

Responses were recorded on whether the participant had ever had sexual intercourse with a commercial sex worker and separately, had ever given money or drugs for sexual intercourse.

### Drug use

History of specific drug use by the participant was asked including alcohol, injected drugs and any drug. The frequency of alcohol use in the past 3 months including five response categories (daily, once a week, once a month, couple of times a year, and never) was determined and recoded into two categories (once a week  $\geq$  and never). Injection drug use and any drug use were recorded as ever use versus no use (note: injected drug use results are not reported owing to an extremely low reported prevalence).

#### Sexual intercourse and drug use

Participants were asked whether at the last sexual intercourse with each sexual partner if the sexual partner had been drinking and in a separate question, using drugs.

### Age-bridging measure: dependent variable

The previous literature regarding age-mixing suggests that a 2-year age gap between an adolescent female and an older male partner increases risk for STIs.<sup>11</sup> In this study, an index was defined as an age-bridger (v non age-bridger) if within 2 months the index had at least two sexual partners who differed in age by  $\geq 2$  years.

### Analyses

All analyses were conducted separately by the cities (Baltimore and Denver) due to study population demographic differences between sites and because previous evidence suggested that sexual networks and their mixing patterns represent local social processes.<sup>15</sup> Summary statistics were calculated to show the enrolment percentages from each venue and to describe the participants and their sexual partners. Bivariate associations between age-bridging (dependent variable) and characteristics and the behaviours of the participants and their sexual partners, including potential confounders, were tested using  $\chi^2$  test or Fisher's exact test for categorical variables, t test for continuous variables and logistical regression analyses. Characteristics and behaviours that were significant at the  $p < 0.05$  level in bivariate analyses were entered into a multi-variable logistic regression model using a backwards-step approach to test for characteristics and behaviours that distinguished age-bridgers from non age-bridgers. The final model included variables significant at the  $p < 0.05$  level and the fit of the model was tested using the Hosmer–Lemeshow goodness-of-fit test. All analyses were performed using STATA Intercooled V.8.0.

## RESULTS

Of the 14–24-year-old asymptomatic males from non-correctional venues who tested positive for chlamydia in the screening project, 43% (83/191) of the males in Baltimore and 70% (149/213) of the males in Denver agreed to participate in the longitudinal study. In Baltimore, 2% (2/83) of the participants were excluded because of their non-heterosexual status, resulting in a final study sample of 81 males. In Denver, 7% (10/149) of the participants were excluded because of their non-heterosexual status and having no sexual partners in the past 2 months, resulting in a final study sample of 139 males.

Table 1 shows the participant and sexual partner baseline characteristics including recruitment venues. In Baltimore and Denver, respectively, participants were on average 17.8 (SD 2.2) and 20.2 (SD 2.1) years of age, 96% and 25% African-American, and had had on average 1.7 (SD 0.7) and 1.7 (SD 0.9) sexual partners in the past 2 months. Of the up to four sexual partners reported in the past 2 months, the average age was 17.5 (SD 3.0) years and 19.4 (3.9) years and mean percentage of African-Americans was 98% and 31% in

**Table 1** Characteristics of participants and their sexual partners in Baltimore and Denver, 2001–2\*

Characteristics	Baltimore (n = 81)	Denver (n = 139)
	n (%) or mean (SD)	n (%) or mean (SD)
Recruitment venue		
STI clinics	45 (45)	14 (9)
Adolescent primary care clinic	54 (55)	3 (23)
School-based health clinics	NA	2 (1)
Drug treatment facilities	NA	14 (9)
Street outreach	NA	53 (32)
Community-based organisations	NA	74 (45)
Age in years	17.77 (2.18)	20.23 (2.12)
Race/ethnicity		35 (25)
African-American	78 (96)	57 (41)
Latino/Hispanic	1 (1)	34 (24)
White, non-Hispanic	0 (0)	13 (9)
Other (American Indian, Asian/Pacific Islander, other)	2 (2)	
Currently enrolled in school	58 (73)	45 (32)
Currently working	37 (46)	94 (68)
STI history, ever	19 (24)	45 (33)
Number of sexual partners in the past 2 months	1.65 (0.74; range 1–8)	1.69 (0.90; range 1–5)
Ever had sexual intercourse with a commercial sex worker	6 (8)	4 (3)
Ever gave money or drugs for sex	6 (8)	4 (3)
Frequency of drunken behaviour in the past 3 months, at least once/week	12 (24)	46 (34)
Ever used drugs including alcohol and marijuana	28 (42)	125 (90)
Age-bridging	17 (21)	36 (26)
Had any sexual partners in the past 2 months†		
Age in years	17.49 (3.04)	19.39 (3.85)
Race/ethnicity	79 (98)	43 (31)
African-American	1 (1)	76 (55)
Latino/Hispanic	1 (1)	55 (40)
White, non-Hispanic	1 (1)	12 (9)
Other (American Indian, Asian/Pacific Islander, other)		
Currently enrolled in school	75 (93)	63 (47)
Last sexual intercourse, sexual partner was drinking	8 (12)	43 (31)
Last sexual intercourse, sexual partner was using drugs	10 (15)	40 (29)
Sexual partner has ever used drugs	23 (28)	n/a
Sexual partner very likely had other partners during relationship	n/a	50 (36)

NA, not ascertained: questions were not ascertained at site; STI, sexually transmitted infection.

\*For some variables, the percentage is based on a smaller N due to missing data.

†Partner data summarised as index indicators.

Baltimore and Denver, respectively. The prevalence of age-bridging was 21% (17/81) in Baltimore and 26% (36/139) in Denver. Among participants with  $\geq 2$  partners, prevalence of age-bridging was 40% in Baltimore and 56% in Denver. Compared with the age of the male index, the most frequent combinations of sexual partners in Baltimore were same age and younger partners (47%) and same age and older partners (29%). Of the age-bridgers in Denver, the most frequent combination of sexual partners were older and younger partners (39%) and same age and younger partners (33%).

Table 2 compares characteristics and behaviours of the participants and their sexual partners for age-bridgers *v* non age-bridgers, in each city. We explore these results more fully in the description given in table 3.

Table 3 shows the bivariate and multivariable associations between (a) age-bridging and individual male characteristics and (b) age-bridging and partner characteristics. In Baltimore in the bivariate analysis, age-bridgers (*v* non age-bridgers) had significantly ( $p < 0.05$ ) more sexual partners in the past 2 months (OR 9.95, 95% CI 3.02 to 32.81) and/or were more likely to have ever given money or drugs for sexual intercourse (OR 12.89, 95% CI 2.05 to 80.90), to have been drunk at least once a week in the past 3 months (OR 5.43, 95% CI 1.36 to

21.69), to have ever used drugs including alcohol and marijuana (OR 4.67, 95% CI 1.11 to 19.62), to have had a sexual partner in the past 2 months who at last sexual intercourse used drugs (OR 4.90, 95% CI 1.19 to 20.15) and/or who at last sexual intercourse was drinking (OR 6.50, 95% CI 1.35 to 31.34).

In Denver in bivariate analysis, age-bridgers (*v* non age-bridgers) had significantly ( $p < 0.05$ ) more sexual partners in the past 2 months (OR 3.91, 95% CI 2.25 to 6.81), and/or were more likely to have been drunk at least once a week in the past 3 months (OR 2.72, 95% CI 1.20 to 6.16), to have had a sex partner in the past 2 months who at last sexual intercourse was drinking (OR 7.35, 95% CI 3.17 to 16.96) and/or who at last sexual intercourse used drugs (OR 5.13, 95% CI 2.26 to 11.63).

In adjusted multivariable analysis in both cities, after controlling for the number of sexual partners in the past 2 months, having a sexual partner in the past 2 months that at last sexual intercourse was drinking was significantly associated with age-bridging (Baltimore AOR 13.42, 95% CI 1.56 to 115.13; Denver AOR: 3.75, 95% CI 1.46 to 9.64,  $p = 0.01$ ). The Hosmer–Lemeshow goodness-of-fit test was not of major importance in both models, indicating that the model prediction did not markedly differ from the observed data.

**Table 2** Characteristics of participants and their sexual partners by age-bridger v non age-bridger status in Baltimore and Denver, 2001–2003\*

Characteristics	Baltimore (n = 81)			Denver (n = 139)		
	Age bridger n (%) or mean (SD)	Non-age bridger n (%) or mean (SD)	p Value†	Age bridger n (%) or mean (SD)	Non-age bridger n (%) or mean (SD)	p Value†
Age in years	17.76 (2.19)	17.77 (2.19)	1.00	20.69 (1.94)	20.07 (2.17)	0.13
Race/ethnicity						
African–American	SS	SS		10 (28)	23 (22)	0.51
White	SS	SS		7 (19)	27 (26)	0.42
Hispanic	SS	SS		19 (53)	40 (39)	0.15
Currently enrolled in school	13 (76)	45 (71)	0.68	25 (69)	69 (67)	0.79
Currently working	9 (53)	28 (44)	0.50	26 (72)	68 (66)	0.49
STI history, ever	5 (31)	14 (22)	0.45	15 (43)	30 (30)	0.15
No of sexual partners in the past 2 months	2.47 (0.72)	1.44 (0.59)	0.00‡	2.44 (0.84)	1.43 (0.76)	0.00‡
Ever had sexual intercourse with a commercial sex worker	2 (13)	4 (7)	0.43	2 (6)	2 (2)	0.29
Ever gave money or drugs for sexual intercourse	4 (31)	2 (3)	0.00‡	1 (1)	3 (8)	0.06
Frequency of drunken behaviour in the past 3 months, at least once/week	7 (47)	5 (14)	0.01‡	19 (56)	27 (32)	0.02‡
Ever used drug including alcohol and marijuana	8 (73)	20 (36)	0.03‡	35 (97)	90 (87)	0.08
<b>Had any sex partners in the past 2 months§</b>						
Race/ethnicity						
Hispanic	SS	SS		24 (67)	52 (50)	0.09
African–American	SS	SS		12 (33)	31 (30)	0.72
Currently enrolled in school	16 (94)	59 (92)	0.79	19 (56)	44 (44)	0.21
During last sexual intercourse, sexual partner was drinking	4 (33)	4 (7)	0.01*	23 (64)	20 (19)	0.00*
During last sexual intercourse, sexual partner used drugs	3 (23)	7 (13)	0.33	20 (56)	20 (20)	0.00*
Sexual partner has ever used drugs	7 (41)	16 (25)	0.19	NA	NA	NA
Sexual partner very likely had other partners during relationship	NA	NA	NA	22 (61)	28 (27)	0.00*

NA, not ascertained: questions were not ascertained at site; SS, small sample size and item not tested; STI, sexually transmitted infection.

\*For some variables, the percentage is based on a smaller n due to missing data.

†Fisher's exact tests, t tests and  $\chi^2$  tests were conducted where appropriate.

‡p < 0.05.

§Partner data summarised as index indicators.

Additionally, we conducted three sensitivity analyses. To determine the extent to which the results for age-bridging were just a reflection of the increased risks associated with  $\geq 2$  sexual partners v one sexual partner, we conducted a sensitivity analysis restricting the study population to individuals with two or more sexual partners in the past 2 months. The results of the sensitivity analysis showed the same direction of findings for all bivariate and multivariable analyses suggesting that the major findings for the full sample were not just a marker for one versus two or more sexual partners.

To determine the sensitivity of our cut-off of  $\geq 2$  years for the age difference between the sexual partners of the index in our age-bridging definition, we conducted two sensitivity analyses—restricting the definition of age-bridging to  $\geq 3$  years and  $\geq 4$  years, separately. The results of these sensitivity analyses were consistent with the full sample in direction and magnitude.

## DISCUSSION

Age-mixing, specifically partnerships between an adolescent girl and a male sexual partner,  $\geq 2$  years older, have been shown to increase risks for STIs among adolescent girls.<sup>3 5 11</sup> In this study, we explored one potential mechanism, age-bridging, which may in part explain the increased risks associated with age-mixing. We used a unique dataset, which includes heterosexual males, aged 14–24 years, infected with chlamydia from two US cities and their reports of sexual partners in the past 2 months. The dataset allowed us to determine if these men have sexual partners who differ in age by  $\geq 2$  years (a behaviour we call age-bridging)

the prevalence of age-bridging and characteristics associated with age-bridging. We hypothesised that age-bridgers might be more likely to transmit infection between networks and that these types of linkages might be more likely to result in a sustained network transmission. Thus, this study brings a sexual network-level perspective to previous age-mixing studies to explore one mechanism of risk, age-bridging and highlights a subgroup of males with increased potential for transmitting STIs.

This study showed that among the study populations, one fifth to one-quarter of the males were age-bridgers. Among participants with two or more partners, 40% of the men in Baltimore and 56% of those in Denver were age-bridgers. These findings are similar to a study among in-school youth aged 13–17 years, which reported that 57% of African–American and 63% of Hispanic boys with two or more sexual partners had partners in two different age groups.<sup>3 11</sup> These data support the idea that adolescent and young adult males provide sexual network linkages between young and older females.

Importantly, our analysis showed that male age-bridgers (v non age-bridgers) engaged in markedly more risky sexual behaviour such as having multiple partners, drug and alcohol use during sexual intercourse, and ever having given money or drugs for sexual intercourse. The cluster of behaviours described here are well known STI risk factors.<sup>5 8 11 21</sup> Previous research by Ellen *et al*<sup>22</sup> in an STI clinic-based study examining risks for syphilis and gonorrhea transmission indicated that older men linked high-risk women such as users of “crack” cocaine to adolescent girls not using crack cocaine. The current



**Table 3** Odds ratios of age-bridging (v non age-bridging) associated with participant characteristics in Baltimore and Denver, 2001–3\*

Characteristics	Baltimore (n = 81)		Denver (n = 139)	
	OR	95% CI	OR	95% CI
Age in years	1.00	0.78 to 1.28	1.15	0.96 to 1.38
Race/ethnicity				
African-American	SS	SS	1.34	0.56 to 3.17
White	SS	SS	0.68	0.27 to 1.73
Hispanic	SS	SS	1.76	0.82 to 3.78
Currently enrolled in school	0.77	0.22 to 2.68	1.12	0.49 to 2.54
Currently working	1.45	0.49 to 4.23	1.34	0.58 to 3.09
STI history, ever	1.59	0.47 to 5.35	1.78	0.80 to 3.93
No. of sexual partners in the past 2 months	9.95	3.02 to 32.81*	3.91	2.25 to 6.81*
Ever had sexual intercourse with a commercial sex worker	2.04	0.34 to 12.26	2.82	0.38 to 20.83
Ever gave money or drugs for sexual intercourse	12.89	2.05 to 80.90*	9.09	0.91 to 90.41
Frequency of drunken behaviour in the past 3 months, at least once/week	5.43	1.36 to 21.69*	2.72	1.20 to 6.16*
Ever used drugs including alcohol and marijuana	4.67	1.11 to 19.62*	5.06	0.64 to 40.11
Had any sexual partners in the past 2 months†				
Race/ethnicity				
Hispanic	SS	SS	1.96	0.89 to 4.34
African-American	SS	SS	1.16	0.52 to 2.61
Currently enrolled in school	1.09	0.35 to 3.41	1.64	0.75 to 3.59
Last sexual intercourse, sexual partner was drinking	6.50	1.35 to 31.34*	7.34	3.17 to 16.96*
Last sexual intercourse, sexual partner used drugs	2.10	0.46 to 9.54	5.13	2.26 to 11.63*
Sexual partner has-ever used drugs	2.10	0.69 to 6.43	NA	NA
Sexual partner very likely had other partners during relationship	NA	NA	4.21	1.89 to 9.35*

NA, not ascertained questions were not ascertained at site; SS, indicates small sample size and item not tested; STI, sexually transmitted infection.

\*For some variables, is smaller due to missing data.

†p<0.05.

‡Partner data summarised as index indicators.

findings support the earlier research and suggest that men who bridge age groups may be the network transmission link between older women with high STI prevalence, such as drug users or women who exchange sexual intercourse for money or drugs, and younger women including adolescents.

Future research should attempt to deal with several of the limitations of this study. First, we have used information about the participants' chlamydia infection status and their most recent sexual partners over a 2-month period as a proxy for potential STI transmission with an underlying hypothesis about the possible direction of transmission. Although all males in this study were infected with chlamydia, we were unable to draw definitive conclusions as to when disease transmission occurred and the direction of disease transmission. Another limitation was that all data collection was egocentric—that is, derived from the infected man and not from his sexual partner(s) and we only asked about up to four of the index participant's sexual partners in the past 2 months whereas they may have had more partners. Enrolling consenting partners may help to address both the aforementioned limitations. Finally, the results of this study may only apply to the sexual networks in each of these urban areas. Similar studies should be conducted among more generalisable study populations and in other urban areas.

This study indicates that asymptomatic chlamydia-infected urban, young men participate in marked rates of age-bridging. The fact that these young males had multiple, age-disparate sexual partnerships within a 2-month period, engaged in risky sexual behaviours and tested positive for chlamydia strongly implicates them as key players in the network of transmission and acquisition of STIs among minority youth. More research is needed to explore these sexual mixing and bridging patterns and the population infection potential.

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## CONTRIBUTIONS OF EACH AUTHOR

The primary author, JJ, was responsible for the analysis and interpretation of data, drafting and revising the manuscript and for providing the final approval of the version to be published. The second author, RL, was responsible for early analyses and interpretation of the data, commenting on revisions to the manuscript and for providing final approval of the version to be published. The third author, LL, was involved in the data collection and management of the study data. The final study authors including CG, JE and CAR were responsible for the conception and design of the study, directing the data collection, guiding interpretation of the data and revisions to the manuscript and giving final approval of the manuscript.

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